



VOLTAGE REGULATING DEVICE FOR ~~CHARGING~~CHARGE PUMP

This application claims the benefit of Taiwan application Serial No. 92114628, filed May 29, 2003.

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001] The invention relates in general to a voltage regulating device, and more particularly to a voltage regulating device for ~~charging~~charge pump.

Description of the Related Art

10 [0002] ~~Charging~~Charge pumps can be used to increase voltage. Take the writeable flash memory for example: ordinary reading only requires a low voltage, e.g., 3V, whereas writing requires a high voltage, e.g. 12V. While ordinary integrated circuit chips (IC chips) normally have only a power supply of small voltage, e.g. 3V, a ~~charging~~charge pump can herein be used to increase the direct current (DC) voltage if a larger-than-3V operating voltage, e.g. 12 V, is needed.

15 [0003] Conventional ~~charging~~charge pumps have a number of varieties such as two-phase ~~charging~~charge pump, four-phase ~~charging~~charge pump, etc. Herein a two-phase ~~charging~~charge pump is illustrated for elaboration. Please refer to FIG. 1, a schematic circuit diagram for a conventional two-phase ~~charging~~charge pump. Two-phase ~~charging~~charge pump 100 includes

diodes D1, D2, D3, and D4, capacitors C1, C2, and C3. For the convenience of elaboration, diodes D1, D2, D3, and D4 are assumed to be ideal diodes with zero turn-on voltage. The positive electrode of diode D1 is coupled to DC power supply Vdd while the negative electrode of diode D1 is coupled to node N1 together with the positive electrode of diode D2 and one terminal of capacitor C1, wherein the other terminal of capacitor C1 receives clock signal CLK. The negative electrode of diode D2 is coupled to node N2 together with the positive electrode of diode D3 and one terminal of capacitor C2, wherein the other terminal of capacitor C2 receives inverse clock signal CLK', inverse of clock signal CLK. The negative electrode of diode D3 is coupled to node N3 together with the positive electrode of diode D4 and one terminal of capacitor C3, wherein the other terminal of capacitor C3 receives clock signal CLK. The negative electrode voltage of diode D4 is exactly the chargingcharge pump output voltage Vo.

[0004] FIG. 2A is a schematic voltage diagram for the nodes of a chargingcharge pump. The voltage for DC power supply Vdd is 3V; the high level and low level voltages for clock signal CLK are 3V and 0V respectively; the initial voltage for node N1 is 3V. When the voltage of clock signal CLK changes to high level, the cross voltage of capacitor C1 still remains at 3V causing V(N1), the voltage of node N1, to be raised to 6V. Similarly, V(N2), the voltage of node N2, is raised to 9V while V(N3), the voltage of node N3, is raised to 12V. Consequently, output voltage Vo is raised to 12V.

[0005] FIG. 2B is a schematic output voltage diagram for a conventional chargingcharge pump. While the chargingcharge pump raises the voltage step by step, output voltage Vo will eventually be raised to 12V. Due to the discharge effect of capacitor C3, however, output voltage

Vo starts to drop slightly when the clock signal CLK coupled to capacitor C3 is at low level, but starts to rise up slightly when clock signal CLK is at high level. In worst cases, output voltage Vo will swing for $\pm 1V$ and result in an undesired ripple-like wave form of the output voltage.

SUMMARY OF THE INVENTION

5 [0006] It is therefore an object of the invention to provide a voltage regulating device for ~~charging~~charge pump.

[0007] According to the object of the invention, a voltage regulating device for ~~charging~~charge pump is provided. The ~~charging~~charge pump outputs an output voltage according to the operation of clock signals. The voltage regulating device includes a number of voltage
10 regulating capacitors whose one terminal is coupled to the output terminal of the ~~charging~~charge pump while the other terminal receives inverse clock signals.

[0008] Other objects, features, and advantages of the invention will become apparent from the following detailed description of the preferred but non-limiting embodiments. The following description is made with reference to the accompanying drawings.

15 BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic circuit diagram for a conventional two-phase ~~charging~~charge pump;

[0010] FIG. 2A is a schematic voltage diagram for the nodes of a chargingcharge pump;

[0011] FIG. 2B is a schematic output voltage diagram for a conventional chargingcharge pump;

[0012] FIG. 3 is a schematic diagram for a voltage regulating device for chargingcharge pump
5 according to a preferred embodiment of the invention;

[0013] FIG. 4 shows the wave form of chargingcharge pump output voltage obtained according to a voltage regulating device of the invention; and

[0014] FIG. 5 is a schematic diagram illustrating the application of the voltage regulating device according to the invention in a four-phase chargingcharge pump.

10 DETAILED DESCRIPTION OF THE INVENTION

[0015] The chargingcharge pump uses the capacitor to raise the DC (direct current) voltage and inevitably results in a slightly rippled wave form of the output voltage. The spirit of the invention lies in coupling a voltage regulating wave form, which is opposite to the ripple of output voltage V_o , to the output terminal of the chargingcharge pump such that the wave form of
15 output voltage V_o goes smoothly and that the quality of power supply can be enhanced.

[0016] FIG. 3 is a schematic diagram for a voltage regulating device for chargingcharge pump according to a preferred embodiment of the invention. In the embodiment, the chargingcharge pump is illustrated using two-phase chargingcharge pump 100. The voltage regulating device is

coupled to two-phase chargingcharge pump 100 wherein chargingcharge pump 100 raises the level of input voltage V_{dd} to the level of output voltage V_o according to clock signal CLK. The voltage regulating device includes voltage regulating capacitors C_s whose one terminal is coupled to the output terminal of chargingcharge pump 100 while the other terminal receives
5 inverse clock signal CLK', inverse of clock signal CLK.

[0017] First of all, the operating principles for chargingcharge pump 100 are discussed below. The initial voltage for node N1 is 3V. When the voltage of clock signal CLK changes to high level, the cross voltage of capacitor C1 still remains at 3V causing V(N1), the voltage of node N1, to be raised to 6V. Similarly, V(N2), the voltage of node N2, is raised to 9V while
10 V(N3), the voltage of node N3, is raised to 12V. Consequently, output voltage V_o is raised to 12V. However, as illustrated in FIG. 2B, when clock signal CLK is at low level, output voltage V_o drops slightly due to the discharge effect of capacitor C3 resulting in an undesired wave form of the output voltage. Particularly when the voltage of clock signal is raised to high level, output voltage V_o will have an abrupt increase leading to an unstable output of voltage.

15 [0018] According to the received inverse clock signal CLK', the voltage regulating capacitor in the invention couples a voltage regulating wave to the output terminal of the chargingcharge pump. Since the inverse clock signals received by voltage regulating capacitors C_s are the inverse signals of the last scaled clock signals of the chargingcharge pump, capacitors C_s can provide appropriate bias in case that the output voltage V_o is insufficient to provide enough bias.
20 When output voltage V_o starts to drop down, the voltage regulating wave couples a positive voltage to output voltage V_o and the output voltage V_o falls smoothly; when output voltage V_o

starts to rise up, the voltage regulating wave couples a negative voltage to output voltage V_o and the output voltage V_o rises smoothly. In doing so, the wave form of output voltage V_o becomes more regulated.

[0019] FIG. 4 shows the wave form of ~~charging~~charge pump output voltage obtained according to a voltage regulating device of the invention. Troughs in dotted lines are wave form before voltage regulating and are sharper than those in solid lines which are wave form after voltage regulating. This comparison shows that the invention does help to regulate the output voltage.

[0020] The voltage regulating capacitors C_s of the invention are appropriately selected capacitors whose capacitance is relatively small compared to the capacitance which the output terminal of the ~~charging~~charge pump embodies. Amplitude of inverse clock signal CLK' received by voltage regulating capacitors C_s will be smaller and become more regulated without affecting the value of output voltage V_o , because the voltage of inverse clock signal CLK' has already been divided by voltage regulating capacitors C_s and the loading capacitor.

[0021] FIG. 5 is a schematic diagram illustrating the application of the voltage regulating device according to the invention in a four-phase ~~charging~~charge pump. Since four-phase ~~charging~~charge pump operates according to four sets of clock signals, namely, CLK_0 , CLK_1 , CLK_2 , and CLK_3 , four sets of voltage regulating devices are needed. These voltage regulating devices include voltage regulating capacitors C_{s0} , C_{s1} , C_{s2} , and C_{s3} which receive inverse clock signals CLK_0' , CLK_1' , CLK_2' , and CLK_3' respectively, to supplement the insufficient bias of output voltage according to the above mentioned principles and produce a more regulated wave

form of output voltage accordingly.

[0022] The voltage regulating device disclosed in the above embodiment of the invention has the advantage of regulating the output voltage of the ~~charging~~charge pump.

[0023] While the invention has been described by way of example and in terms of a preferred embodiment, it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

ABSTRACT OF THE DISCLOSURE

A voltage regulating device for ~~charging~~charge pump is disclosed. The ~~charging~~charge pump outputs an output voltage according to the operation of clock signals. The voltage regulating device includes a number of voltage regulating capacitors whose one terminal is coupled to the output terminal of the ~~charging~~charge pump while the other terminal receives inverse clock signals.

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